

**Geologic Resources Inventory Workshop Summary  
Timpanogos Cave National Monument, Utah  
May 10-11, 1999**

**National Park Service  
Geologic Resources Division  
and  
Natural Resources Information Division**

Version: Revised Draft of June 2, 1999

**EXECUTIVE SUMMARY**

An inventory workshop was held at Timpanogos Cave National Monument on May 10-11, 1999 to view and discuss the park's geologic resources, to address the status of geologic mapping for compiling both paper and digital maps, and to assess resource management issues and needs. Cooperators from the NPS Geologic Resources Division (GRD), Natural Resources Information Division (NRID), Timpanogos Cave NM (interpretation, resource management and superintendent), Utah Geological Survey, and local academic researchers were present for the two-day workshop. ([\*see Appendix A, Timpanogos NM Geological Resources Inventory Workshop Participants, May 10-11, 1999\*](#))

Day one involved a two-part field trip first led by University of Arizona Geologist Kurt Constenius, who has done extensive research on the regional tectonics and geologic structure, followed by a tour through the Timpanogos Cave system led by National Park Service (NPS) Geologic Resources Division (GRD) Cave Specialist Ron Kerbo.

[\*An on-line slide show of the highlights of the field trip can be found at\*](http://www.nature.nps.gov/grd/geology/gri/ut/tica/field_trip_tica)

Day two involved a scoping session to present overviews of the NPS Inventory and Monitoring (I&M) program, the Geologic Resources Division, and the ongoing Geologic Resources Inventory (GRI) for Colorado and Utah. Round table discussions involving geologic issues for Timpanogos Cave NM included interpretation, the UGA Millennium 2000 guidebook featuring the geology of Utah's National and State parks, paleontological resources, the status of cooperative geologic mapping efforts, sources of available data, geologic hazards, unique geologic features, potential future research topics, and action items generated from this meeting. Brief summaries of each follows.

# **Timpanogos Cave NM GRI Workshop Summary:**

## ***May 10-11, 1999 (cont'd)***

### **OVERVIEW OF GEOLOGIC RESOURCES INVENTORY**

After introductions by the participants, Joe Gregson (NPS-NRID) presented an overview of the NPS I&M Program, the status of the natural resource inventories, and the geological resources inventory ([see Appendix B, Overview of Geologic Resources Inventory](#)).

He also presented a demonstration of some of the main features of the **digital geologic map** for the Black Canyon of the Gunnison NM and Curecanti NRA areas in Colorado. This has become the prototype for the NPS digital geologic map model as it ideally reproduces all aspects of a paper map (i.e. it incorporates the map notes, cross sections, legend etc.) with the added benefit of being a GIS component. It is displayed in ESRI ArcView shape files and features a built-in help file system to identify the map units. It can also display scanned JPG or GIF images of the geologic cross sections supplied with the map. The cross section lines (ex. A-A') are subsequently digitized as a shape file and are hyperlinked to the scanned images.

***For a recap on this process, go to: [http://www.nature.nps.gov/grd/geology/gri/blca\\_cure/](http://www.nature.nps.gov/grd/geology/gri/blca_cure/) and view the various files in the directory.***

The geologists at the workshop familiar with GIS methods were quite impressed with this method of displaying geologic maps digitally; Gregson is to be commended for his accomplishments.

Tim Connors (NPS-GRD) followed with a presentation summary of the up-to-date results of the Colorado GRI program. The status of each park area for geologic mapping inventories, digitizing maps, assembling bibliographies, preparing reports and defining deliverable dates for the NPS units in Colorado was discussed, as the Utah parks will follow a similar process.

---

### **INTERPRETATION**

The GRI aims to help promote geologic resource interpretation within the parks and GRD has staff and technology to assist in preparation of useful materials including developing site bulletins and resource management proposal (RMP) statements appropriate to promoting geology. Jim Wood (GRD) and Melanie Moreno (USGS-Menlo Park, CA) have worked with several other NPS units in developing web-based geology interpretation themes, and should be considered as a source of assistance should the park desire.

During the walk up to the cave, the topic of how to improve the trailside exhibits was discussed in depth with Suzanne Flury. Many suggestions involved creating stratigraphic column signs with the theme of "you are here" in the geologic column and also giving geologic ages.

## **Timpanogos Cave NM GRI Workshop Summary:**

***May 10-11, 1999 (cont'd)***

It was also noted that in the near future, there will be a joint NPS-US Forest Service (USFS) visitor center at the mouth of American Fork Canyon. It was suggested that a 3-dimensional model of the cave would be a nice feature of such a visitor center. It was suggested that interpreters from both agencies try to work together to promote the regional geologic story using the latest technologies as American Fork Canyon and Mount Timpanogos are major features of the Salt Lake City skyline. Being within such a short driving distance of such a large metropolitan area has turned TICA into an "urban" park. Because of this, Kit Mullen sees TICA as having the best opportunity to combine with the State of Utah for interpretation, education, and protection of resources.

Lee Allison (UGS) mentioned that the UGS has targeted the NPS as a major partner for the next decade. They are currently assisting the NPS with their geologic mapping program and geologic extension services to facilitate information transfer to the public. Sandy Eldredge is available to conduct workshops with park personnel (including seasonals) and to work with Suzanne Flury regarding the interpretive trail signs. Specific programs that they can relay to park staff involve general geology, the geology of Utah, and the specific geology of NPS parks. They also have a brochure on the Geologic History of Utah that has been used by other parks such as Zion. They like to coordinate with other government agencies (BLM, USFS etc.) to minimize training sessions and redundancy. They think of it as "training the trainers".

Lee also mentioned that the UGS has a paleoecology team (headed by Dave Madsen) working in the western Utah desert studying both the human and paleoclimate history in caves. They may be able to help in studying age relations in the Timpanogos Cave System. This is further discussed in "Future Research Topics".

---

### **UGA GUIDEBOOK ON UTAH'S NATIONAL AND STATE PARK AREAS**

A guidebook treating the geology of 27 of Utah's national and state parks and monuments will be compiled for publication in September 2000. This compilation will be a snapshot into the geology of each park and covers most facets of what the GRI is trying to develop for each park for a final report (i.e. cross sections, simplified geologic map, general discussions of rocks, structure, unique aspects of park geology, classic viewing localities). Each author will be *encouraged* to get with NPS staff interpreters to develop a product that aims at a wide audience (the common visitor, the technical audience and the teaching community). Timpanogos Cave NM author will be Alan Mayo (BYU), who participated in the scoping session. He may be consulting with Kurt Constenius for background on the regional geology for his paper.

Also, a CD-ROM will be distributed with the publication featuring road and trail logs for specific parks as well as a photo glossary and gallery. The photo glossary will describe certain geologic features (i.e. what is crossbedding?). It is highly suggested that all authors work closely with NPS staff to make sure that any road and trail logs featured are in areas that are open to the public, and will not create major disturbances to fragile ecosystems (i.e. cryptogamic soils, protected cave and paleontological resources, etc.)

## Timpanogos Cave NM GRI Workshop Summary: *May 10-11, 1999 (cont'd)*

These will also be available as web-downloadable Adobe Acrobat PDF files. The UGA cannot copyright this material because it is funded with state money, so it can be distributed widely and freely, which will also benefit the purposes of the GRI. Additional reprints are not a problem because of the digital nature of the publication and the UGA board is committed to additional printings as needed. UGA normally prints 1000 copies of their publications because they become dated after about five years; that will probably not be an issue for this publication. Prices for the full-color guidebook are estimated to be approximately \$25/copy, and sales are expected to be high (exact estimates for Capitol Reef NM were 125 copies/year). A website for the guidebook is forthcoming in October 1999.

Field Trips will be held in September 2000. Currently, four field trips are scheduled:

1. Arches NP, Canyonlands NP, Dead Horse Point State Park (SP)
2. Antelope Island SP and Wasatch Mountain SP
3. Zion NP, Cedar Breaks NM, Snow Canyon SP and Quail Creek SP
4. Dinosaur NM, Flaming Gorge NRA, and Red Fleet SP

*Note: Trips 1 and 2 will run concurrently and Trips 3 and 4 will also run concurrently.*

Many other benefits are anticipated from this publication and are enumerated below:

- This type of project could serve as a model for other states to follow to bolster tourism and book sales promoting their state and its geologic features.
- Sandy Eldredge (UGS) will be targeting teaching communities for involvement in the field trips; hopefully teachers will pass on what they have learned to their young audience.
- The language is intended to appeal to someone with a moderate background in geology and yet will be very informative to the educated geologist.
- The publication may be able to serve as a textbook to colleges teaching Geology of National Parks (in Utah).
- A welcomed by-product could be roadlogs between parks in Utah for those visiting multiple parks, perhaps with a regional synthesis summarizing how the overall picture of Utah geology has developed.

### PALEONTOLOGICAL RESOURCES

After the meeting, Vince Santucci (NPS-GRD Paleontologist) was consulted for insight into the paleontological resources of the area. He mentions a series of fossiliferous units in American Fork Canyon in the following geologic units:

- The *Cambrian* **Ophir Formation** has marine invertebrates including an assemblage of trilobites.

## Timpanogos Cave NM GRI Workshop Summary: *May 10-11, 1999 (cont'd)*

- The *Mississippian Deseret Limestone*, the cave forming unit at TICA, has a variety of marine invertebrates.
- *Precambrian* trace fossils have been reported from the American Fork Canyon area.
- There are other units that have not yet been surveyed and are potentially fossiliferous.

He also reports receiving a copy of a TICA RMP (resource management plan) Project Statement from past Superintendent Cordell Roy in 1997. This project statement proposed the excavation of paleontological resources from various cave fill sites at the monument. Rod Horrocks was very interested in initiating this project. A Paleontology Intern, Christian George, was recruited from Franklin and Marshall University, PA, to assist in the project.

Packrat middens and cave fill samples were obtained in 1998. One collection was made from a midden in the Organ Pipe Room of Hansen Cave. Small collections were made in Hidden Mine Cave and Boneyard Cave. There is a small collection of bones made during 1939 from Grotto Cave. Ron Kerbo is currently funding Carbon-14 dating for a few of the samples. Christian George has analyzed the faunal material under the supervision of paleontologists at the Academy of Natural Sciences in Philadelphia and his undergraduate advisor. The results of Christian's analysis are being published in the 4th NPS Paleo Research Volume.

The monument currently has 59 cataloged paleontology specimens and will more than double with the curation of the cave fill material collected in 1998.

Santucci has also co-authored several Paleontological Surveys and hopes to complete one for TICA. Similar surveys have been done for Yellowstone and Death Valley NP's and have shed valuable new information on previously unrecognized resources. These surveys involve a literature review/bibliography and recognition of type specimens, species lists, and maps (which are unpublished to protect locality information), and also make park specific recommendations for protecting and preserving the resources.

The Death Valley Survey will be available soon. The **Yellowstone** Survey is already available on-line at:

[http://www.nature.nps.gov/grd/geology/paleo/yell\\_survey/index.htm](http://www.nature.nps.gov/grd/geology/paleo/yell_survey/index.htm)

and is also available as a downloadable PDF at

<http://www.nature.nps.gov/grd/geology/paleo/yell.pdf>

Vince suggests paleontological resource management plans should be produced for Timpanogos Cave involving some inventory and monitoring to identify human and natural threats to these resources. Perhaps someone on the park staff could be assigned to coordinate paleontological resource management and incorporate any findings or suggestions into the parks general management plan (GMP). It would be useful to train park staff (including interpreters and law enforcement) in resource

## Timpanogos Cave NM GRI Workshop Summary:

***May 10-11, 1999 (cont'd)***

protection, as the fossil trade "black market" has become quite lucrative for sellers and often results in illegal collecting from federal lands.

Collections taken from this area that now reside in outside repositories should be tracked down for inventory purposes. Fossils offer many interpretive themes and combine a geology/biology link and should be utilized as much as possible in interpretive programs.

---

### **STATUS OF GEOLOGIC MAPPING EFFORTS FOR TIMPANOGOS CAVE NM**

Currently, the UGS is mapping in Utah at three different scales:

- **1:24,000** for high priority areas (i.e. National and State parks)
- **1:100,000** for the rest of the state
- **1:500,000** for a compiled state geologic map

The UGS plans to complete mapping for the entire state of Utah within 10-15 years at 1:100,000 scale. For **1:100,000** scale maps, their goal is to produce *both* paper and digital maps; for **1:24,000** scale maps, the only digital products will be from "special interest" areas (i.e. areas such as Zion and growing metropolitan St. George). The UGS simply does not have enough manpower and resources to do more areas at this scale. UGS mapping goals are coincident with those of the National Geologic Mapping Program of the USGS.

Kurt Constenius showed the group a compilation of the four major 1:24,000 scale quadrangles that encompass the Timpanogos Cave region ([See Appendix C, Timpanogos Cave NM Index of Geologic Maps, 1:24,000 Scale, and Appendix D, Timpanogos Cave NM Index of Geologic Maps, 1:48,000 Scale](#)):

- **Dromedary**
- **Brighton**
- **Timpanogos Cave**
- **Aspen Grove**

He noted that the map edges match quite well on all four quadrangles and that there is a summary of the geology, stratigraphy, and geologic history for the area that accompanies the maps.

All four quadrangles are published, but are not believed to be in digital format. The main author on these maps was Arthur Alan Baker and most were published in the 1960s prior to digital compilations. The NPS only requires digitization of the Timpanogos Cave quadrangle (GQ-132), but welcomes digitization of the surrounding area by other agencies, if possible. Grant Willis needs to be consulted to find out the possibility of the UGS digitizing this quadrangle.

Constenius noted that he is currently working with the UGS and Jim Coogan (Denver, CO) to compile the **Provo 30x60 quadrangle** at 1:100,000. This project encompasses some minor changes to the existing Baker quadrangles incorporating modern thought into the stress field systems and thrust belts using some aerial reconnaissance. Work

## **Timpanogos Cave NM GRI Workshop Summary:**

### ***May 10-11, 1999 (cont'd)***

will begin in July 1999 and will be a high priority for completion, but is expected to be a 3-year project.

The NPS feels digitization of the Timpanogos Cave quadrangle can begin immediately, and that any refinements to the area by Constenius and Coogan could be incorporated at a later time.

#### **OTHER SOURCES OF NATURAL RESOURCES DATA FOR TIMPANOGOS CAVE**

- The UGS has a significant quadrangle database that they have furnished to NRID for the entire state of Utah.
  - NRID has compiled a geologic bibliography for numerous parks and monuments, including Timpanogos Cave. Visit the website at:  
<http://165.83.36.151/biblios/geobib.nsf>; user id is "geobib read", password is "anybody".
  - It was mentioned that Rod Horrocks worked on a map of the area at ~1:100,000 scale that is hand-drawn and should probably be digitized.
- 

#### **GEOLOGIC HAZARDS**

There are numerous issues related to geologic hazards in and around Timpanogos Cave NM. Below is a brief list of some mentioned during the scoping session:

- Rockfalls in American Fork Canyon have caused human fatalities and have damaged trails
  - Debris flows in picnic areas have buried gates and posed threats to the public
  - Slip/fall hazards are present on many trails within the canyon, especially during cooler weather
  - Flash floods and snow avalanches occasionally occur within American Fork Canyon
  - Low ceiling heights in the caves pose both a potential danger to visitors who may hit their head, and to speleothems that are hit by those heads
  - Significant earthquake potential exists along the Wasatch Fault of the mountain front just west of American Fork Canyon
  - There is a potential for Radon in the caves; TICA has study with official report
  - Drop-offs (> 1 meter) and narrow passages within the cave exist and pose safety hazards
-

# **Timpanogos Cave NM GRI Workshop Summary:**

## ***May 10-11, 1999 (cont'd)***

### **UNIQUE GEOLOGIC FEATURES**

The Timpanogos Cave area has some spectacular geologic features; a few are listed below:

- Timpanogos Cave system with three distinct cave areas/names: Hansen Cave, Middle Cave, Timpanogos Cave.
  - Walls of the American Fork Canyon and the path leading up to the cave
  - Speleothems: flowstone, Helictites, stalactites, stalagmites
  - Speleogens: features related to genesis of caves that was created as cave was formed
  - Fracture flow ground-water river system
  - Paleoclimate record in minerals and sediments (especially cobbles); pack rat middens in cave;
  - human signatures in the cave
  - Paleo river system and paleohydrology (sediments in cave cobbles, etc.)
  - Fault and fracture system on cave control
  - Box Elder Peak anticline is major crustal scale anticline
  - Tibble Fork half-graben
  - Wasatch Fault that marks the beginning of the American Fork Canyon
- 

### **POTENTIAL RESEARCH TOPICS FOR TIMPANOGOS CAVE NM**

A list of potential research topics and future needs includes the following:

- A detailed 3-dimensional cartographic survey of the cave interior including features (speleothems and speleogens) that follows standards and guidelines
- Determination of the age, origin, and geologic history of the cave system and American Fork Canyon
- use Uranium series dating (or C-14 if young enough) or U-Pb (if old enough) to determine when active speleological deposition began while extracting paleomagnetic data if possible; determine number of depositional episodes
- Study palynology and stratigraphy of sediments and cores. It was mentioned that 13' of flowstone was cored; try to locate this core and where it was taken from within the cave.
- Determine age of canyon cutting using apatite fission tracks for peaks and surface exposure ages for minimum age of canyon from the exposed flatirons
- date small vugs in other stratigraphic units for timing of deposition; use isotopic composition of CO<sub>3</sub> minerals to determine source (hydrothermal or other)
- collect current drip waters to determine potential for precipitation (deposition) or dissolution (erosion) by current chemical composition parameters (pH)

## **Timpanogos Cave NM GRI Workshop Summary: May 10-11, 1999 (cont'd)**

- determine air flow directions in the cave for use in interpreting the direction of deposition of speleothems
  - use resistivity to locate cavities in other stratigraphic units
  - Conduct a detailed study of fractures, faults and bedding within the area
  - Conduct a minerals inventory within the cave (aragonite, calcite, etc.)
  - Review catalog of different types of speleothems catalogued so far for accuracy for IM purposes
  - Use pressure transducer to study storms moving in and out of cave system to determine pneumatic permeability and the exchange of air within American Fork Canyon
  - Study CO2 concentration within the cave
- 

### **ACTION ITEMS**

Many follow-up items were discussed during the course of the scoping session and are reiterated by category for quick reference.

### **Interpretation**

- More graphics and brochures emphasizing geology and stratigraphy along the trail to the cave that target the average enthusiast should be developed. It was suggested to present a stratigraphic column all along the trail stops with a "you are here" arrow. If TICA needs assistance with these, please consult GRD's Jim Wood ([jim.f.wood@nps.gov](mailto:jim.f.wood@nps.gov)) or Melanie Moreno at the USGS-Menlo Park, CA ([mmoreno@usgs.gov](mailto:mmoreno@usgs.gov)).
- Consult with UGS Geologic Extension Services (Sandy Eldredge) for specific training sessions offered for park staff

### **Paleontological and Speleological Resources**

- Develop an in-house plan to inventory, monitor and protect significant resources from threats; assign staff to oversee
- Locate collections taken from the park residing in outside repositories

### **Geologic Mapping**

- Maintain UGS-USGS-NPS cooperation to reap all possible products from existing work to benefit the NPS GRI

### **Natural Resource Data Sources**

## **Timpanogos Cave NM GRI Workshop Summary:**

### ***May 10-11, 1999 (cont'd)***

- There is a potential for Radon in the caves; TICA has study with official report that should be consulted and reviewed by GRD
- Ascertain any maps that Rod Horrocks may have worked on; It was mentioned that Rod Horrocks worked on a map of the area at ~1:100,000 scale that is hand-drawn and should probably be digitized

#### **Miscellaneous**

- Consult with Rod Horrocks (former TICA cave specialist) on his concerns
- Review proposed research topics for future studies within Timpanogos Cave NM
- Develop more partnerships with BYU beneficial to research community and TICA
- If necessary, consult with other "urban" parks (Mount Rainier) to see how they handle the impacts associated with high visitation brought in from large urban areas
- Provide the NPS "Cave Link" contact list to TICA to establish better communications with other cave specialists in the NPS (Joel Despain, John Roth, etc.)
- There are some human signatures in the cave and these need to be catalogued and recorded as an important cultural resource. Cultural Resources Center folks should be contacted at Santa Fe.

**APPENDIX A**  
**Timpanogos Cave NM Geological Resources Inventory Workshop Participants**  
**May 10-11, 1999**

<b>NAME</b>	<b>AFFILIATION</b>	<b>PHONE</b>	<b>E-MAIL</b>	<b>Field Trip</b>	<b>Scoping Session</b>
Joe Gregson	NPS, Natural Resources Information Division	(970) 225-3559	<a href="mailto:Joe_Gregson@nps.gov">Joe_Gregson@nps.gov</a>	X	X
Tim Connors	NPS, Geologic Resources Division	(303) 969-2093	<a href="mailto:Tim_Connors@nps.gov">Tim_Connors@nps.gov</a>	X	X
Ron Kerbo	NPS, Geologic Resources Division Cave Specialist	(303) 969-2097	<a href="mailto:Ron_Kerbo@nps.gov">Ron_Kerbo@nps.gov</a>	X	X
Marsha Davis	NPS, Columbia Cascades Support Office	(206) 220-4262	<a href="mailto:Marsha_Davis@nps.gov">Marsha_Davis@nps.gov</a>	X	X
Alan Mayo	Brigham Young University	(801) 378-2338	<a href="mailto:Alm@byu.edu">Alm@byu.edu</a>	X	X
Steve Nelson	Brigham Young University	(801) 378-8688	<a href="mailto:Stn@byu.edu">Stn@byu.edu</a>		X
Camille Durrant	NPS, TICA	(801) 785-5728	<a href="mailto:Durranta@suu.edu">Durranta@suu.edu</a>	X	X
Michael Gosse	NPS, TICA	(801) 756-5239	<a href="mailto:Michael_Gosse@nps.gov">Michael_Gosse@nps.gov</a>	X	X
Quincy Bahr	NPS, TICA	(801) 768-8457	<a href="mailto:Bahrqu@uvsc.edu">Bahrqu@uvsc.edu</a>	X	X
Suzanne Flory	NPS, TICA	(801) 756-5239	<a href="mailto:Suzanne_Flory@nps.gov">Suzanne_Flory@nps.gov</a>	X	
Kit Mullen	NPS, TICA Superintendent	(801) 756-5239	<a href="mailto:Kit_Mullen@nps.gov">Kit_Mullen@nps.gov</a>		X
Charles Acklin	NPS, TICA Volunteer	(435) 645-9666	<a href="mailto:Cma@gameofwork.com">Cma@gameofwork.com</a>	X	
Kurt Constenius	University of Arizona	(520) 219-5433	<a href="mailto:Jklm@azstarnet.com">Jklm@azstarnet.com</a>	X	X
Grant Willis	Utah Geological Survey	(801) 537-3355	<a href="mailto:Nrugs.gwillis@state.ut.us">Nrugs.gwillis@state.ut.us</a>	X	
Sandy Eldredge	Utah Geological Survey	(801) 537-3325	<a href="mailto:Nrugs.seldredg@state.ut.us">Nrugs.seldredg@state.ut.us</a>	X	X
Lee Allison	Utah Geological Survey, Chief	(801) 537-3301	<a href="mailto:Nrugs.lallison@state.ut.us">Nrugs.lallison@state.ut.us</a>		X

## **APPENDIX B**

### **Overview of Geologic Resources Inventory**

The NPS Geologic Inventory is a collaborative effort of the NPS Geologic Resources Division (GRD) and Inventory and Monitoring Program (I&M) with assistance from the U.S. Geological Survey (USGS), American Association of State Geologists (AASG), and numerous individual volunteers and cooperators at NPS units, colleges, and universities.

From the perspective of the servicewide I&M Program, the primary focus (Level 1) of the geological inventory is

1. to assemble a bibliography of associated geological resources for NPS units with significant natural resources,
2. to compile and evaluate a list of existing geologic maps for each unit,
3. to develop digital geologic map products, and
4. to complete a geological report that synthesizes much of the existing geologic knowledge about each park. The emphasis of the inventory is not to routinely initiate new geologic mapping projects, but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System.

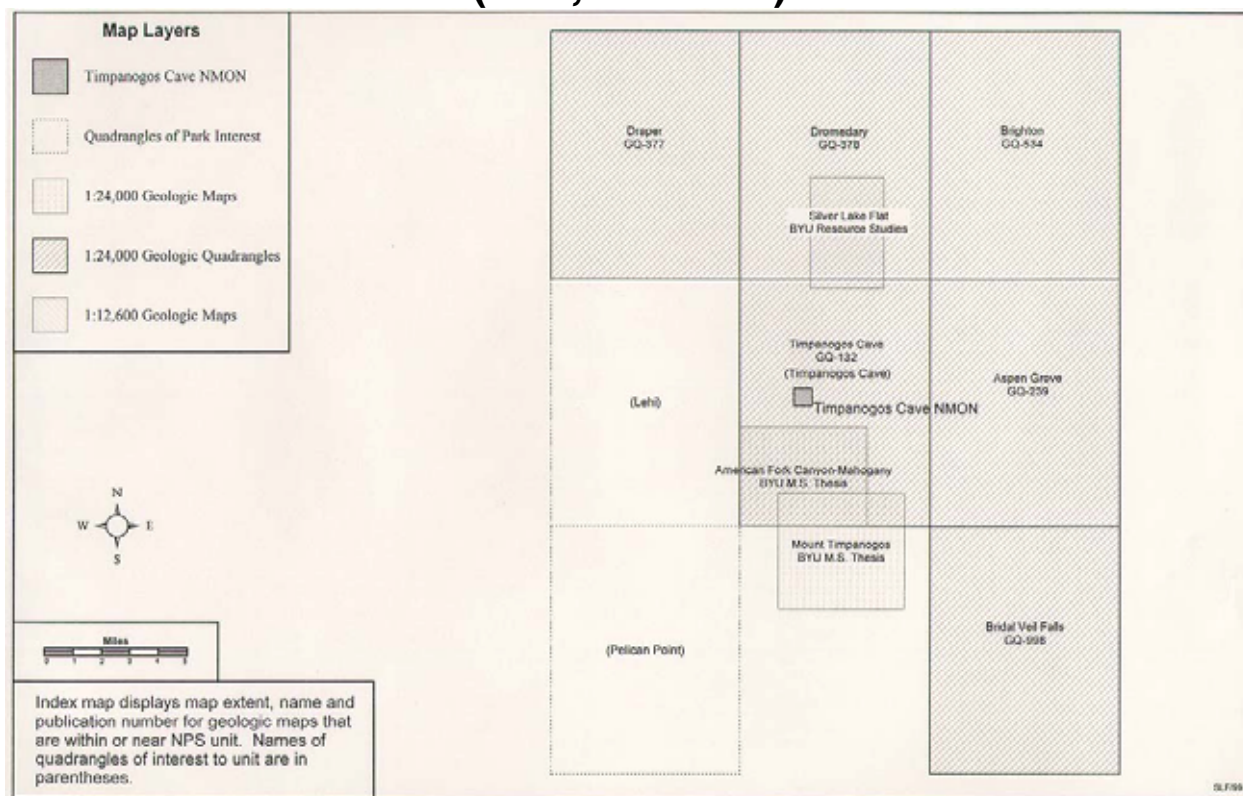
The NPS Geologic Resources Division is an active participant in the I&M Program and has provided guidance and funding in the development of inventory goals and activities. GRD administers the Abandoned Mine Lands (AML) and Geologists In Parks (GIP) programs which contribute to the inventory. NPS paleontologists, geologists, and other natural resource professionals also contribute to inventory planning and data. A major goal of the collaborative effort is to provide a broad baseline of geologic data and scientific support to assist park managers with earth resource issues that may arise.

For each NPS unit, a cooperative group of geologists and NPS personnel (the Park Team) will be assembled to advise and assist with the inventory. Park Teams will meet at the each NPS unit to discuss and scope the geologic resources and inventory, which is the subject of this report. If needed, a second meeting will be held at a central office to evaluate available geologic maps for digital production. After the two meetings, digital geologic map products and a geologic report will be produced. The report will summarize the geologic inventory activities and basic geology topics for each park unit. Due to the variety of geologic settings throughout the NPS, each report will vary in subject matter covered, and section topics will be adapted as needed to describe the geologic resources of each unit. Whenever possible the scientific sections of the report will be written by knowledgeable cooperators and peer reviewed for accuracy and validity.

# APPENDIX C

## Timpanogos Cave NM

### Index of Quadrangle Maps (1:24,000 scale)



# APPENDIX D

## Timpanogos Cave NM

### Index of Quadrangle Maps

(1:48,000 scale)

